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(54) Stress-isolating electrical connections

(57) An attenuator-type head (10) for an electrical instrument probe has an input resistor (44) in the form of a thick film deposit on an elongate ceramic substrate (46) mounted between a pair of resilient conductive pads (52, 54) compressed between the ends of the substrate and the adjacent inner end walls of spaced insulating members (22, 26) which support signal input (tip) and output (tail) leads (28, 36).

The pads serve both to interconnect the ends of the resistor to the adjacent leads and to minimize or prevent the transmission of shear forces from the leads to the resistor.

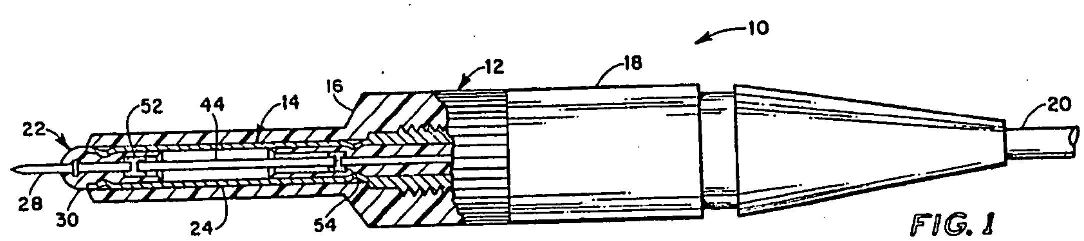

FIG. 1

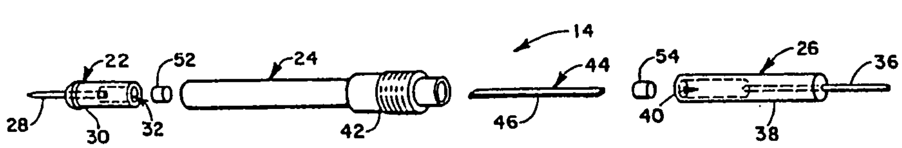

FIG. 2

The drawing originally filed was informal and the print here reproduced is taken from a later filed formal copy.

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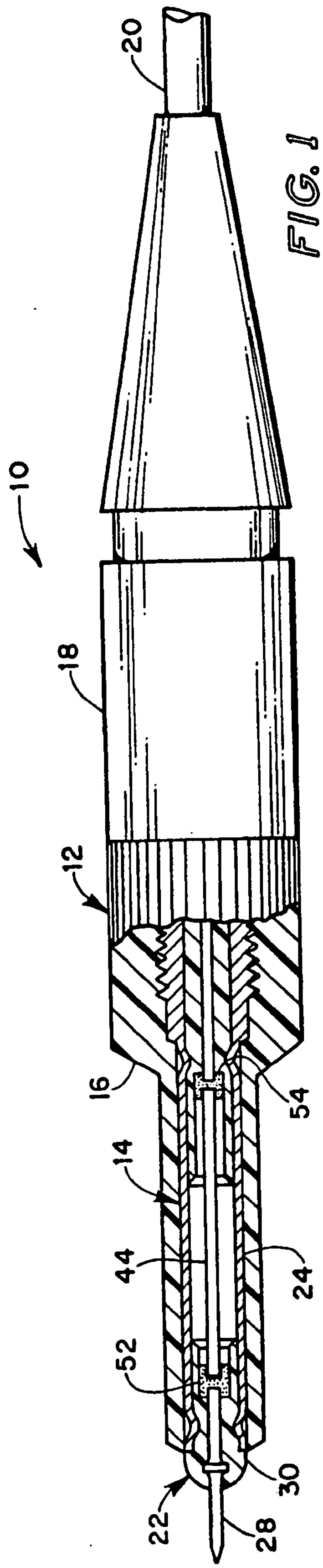


FIG. 1

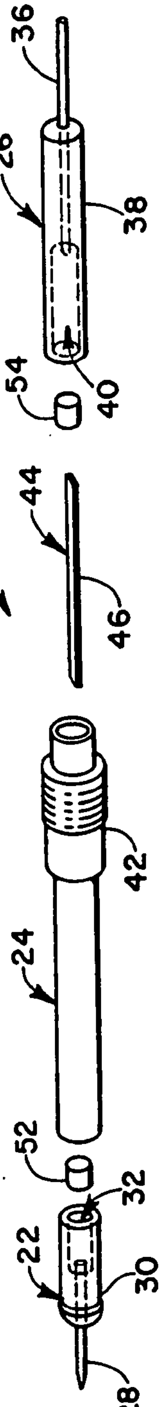
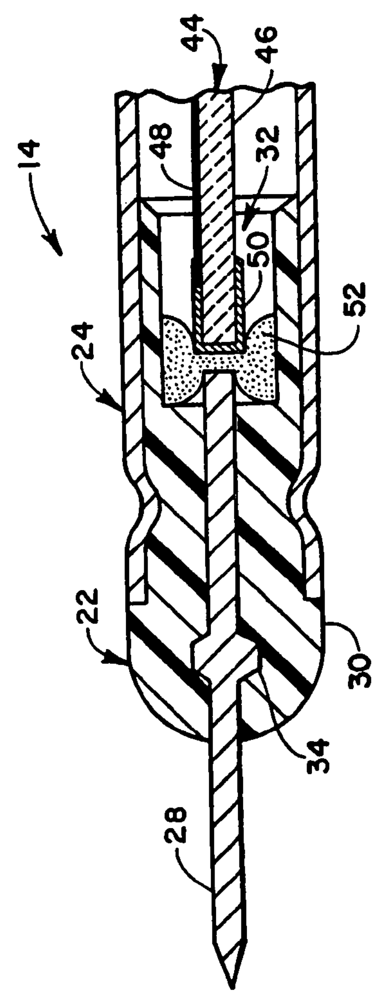


FIG. 2

FIG. 3



transmission of shear forces from the leads to the resistor.

A more complete understanding of the present invention and its various features, advantages and objectives may be had by referring to the following detailed description and the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a side view, partly broken away and partly in section, of a miniature probe head constructed according to a preferred embodiment of the invention;

FIG. 2 is an exploded view of the tip assembly incorporated in the FIG. 1 probe; and

FIG. 3 is an enlarged cross-sectional view on an enlarged scale showing the assembled probe tip assembly in greater detail.

DETAILED DESCRIPTION

Referring now to the drawings, wherein like numerals indicate like elements throughout, an electrical probe head 10 incorporating the improved circuit element mounting and interconnecting method of the invention is shown in FIG. 1. The illustrated head forms part of a miniature, passive, attenuator-type voltage probe suitable for use with a cathode-ray oscilloscope. It will be understood, however, that the invention is useful in a variety of other types of electrical equipment, particularly those employing strain sensitive components.

Probe head 10 has an elongate narrow body formed in two interconnected sections: a forward section 12, which includes a metal-bodied component assembly 14 with a removable insulating sleeve 16, and a unitary rearward section 18. The component assembly is joined within section 18 to a coaxial cable 20, which carries electrical signals from the probe head to a suitable termination (not shown).

Referring to FIGS. 2 and 3 along with FIG. 1, component assembly 14 includes a nose piece 22, an elongate metal barrel, or housing, 24 and a tail piece 26. The nose piece is composed of a rigid metal rod, or tip, 28 molded in an elongate, generally cylindrical plastic body 30 that contains a rearward-opening cavity 32. The inner end of tip 28, which is anchored in body 30 by an intergral collar 34 (FIG. 3), projects a short distance into cavity 32 as shown. Tail piece 26 is of similar construction, and includes a metal rod 36 molded in a cylindrical plastic body 38. The inner end of the rod extends into a forward-facing cavity 40 in body 38. Rod 36, which serves as a signal output lead for assembly 14, suitably is a length of nickel wire. Probe tip 28 is subjected to considerable lateral pressure during normal use, and should therefore be made of a high strength metal having good conductivity characteristics. Tempered beryllium-copper, nickel plated for corrosion protection, has been used with good results. Plastic bodies 30 and 38 preferably are formed of an injection-moldable material with good mechanical properties and superior electrical characteristics, such as "Halar", a fluoro-carbon resin available from Allied Chemical. Housing 24 is a relatively long, thin tubular member having a raised, externally-threaded shoulder 42 adjacent its rear end to accommodate internally-threaded sleeve 16 (FIG. 1). The housing is formed of a hard, conductive metal, suitably a beryllium-copper alloy. For corrosion protection and improved conductivity at high frequencies, the housing may be provided with a thin covering of gold, silver or a suitable alloy such as a semi-bright deposit of copper (55—60%), tin (25—30%) and zinc (14—18%).

Also included in component assembly 14 is an electrical circuit element 44 in the form of a ceramic substrate 46 bearing a strip-like, deposited resistance element 48 (FIG. 3). Thick-film metal (e.g., gold) wrap-around bands 50 are provided at both ends of the substrate for making reliable, low resistance connections to the resistance element, which has a value appropriate to the desired attenuation factor of the probe. Circuit element 44 may, if required, also include a deposited thick film shunt capacitor, suitably located on the opposite face of substrate and connected to the resistance element by the wrap-around bands.

Disposed within cavities 32 and 40 of the nose and tail pieces are resiliently-deformable conductive bodies 52 and 54, respectively. The conductive bodies, which may be formed of a conductive elastomer or a compressed mass of fine wire, establish low resistance, compressive interconnections between the inner, exposed ends of the metal rods in each cavity and the adjacent ends of the circuit element. The resilient bodies also surround and grasp the ends of the circuit element and restrain it against movement within the metal housing. The resilient nature of the interconnections established by bodies 52 and 54 prevents, or at least significantly minimizes, the transmission of shear forces to circuit element 44. Compressive forces are transmitted with only minimal attenuation. However, since the modulus of compression of the circuit element (i.e. its ceramic substrate) is very high, such forces will have no significant affect on the value of the resistance element.

Suitable materials for the conductive bodies include elastomers containing finely-divided metal or other conductive particles in sufficient quantity to provide low resistance connections when compressed. Such materials are commercially available for use as gaskets to prevent EMI (electromagnetic interference) radiation from electronic equipment. A conductive silicone elastomer sold by Chromerics, Inc. as Part No. 10—04—2561—1250 has been used with excellent results. Also useful are compressed masses of fine, resilient wires, known as "Fuzz Buttons", which resemble small, gold-plated steel wool pads.

Another advantage of the invention is the relative simplicity of the assembly process, making it adaptable for automated manufacture.

SPECIFICATION

Shear stress-isolating interconnection for electrical circuit element

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention is concerned generally with the mounting and interconnection of electrical circuit elements. More particularly, the invention is concerned with an improved method and means for simultaneously mounting and interconnecting a mechanical stress-sensitive element to minimize or eliminate strain gauge effects.

2. Description of the Prior Art

Oscilloscopes, digital counters, and other electronic test instruments usually are equipped with one or more signal input probes, which the user connects to a circuit or device under test. Of the various available types, passive voltage-sensing probes are the most common, particularly when analog signals are being investigated. A typical probe of this type will include a signal sensing "head" having a long, thin, insulated body with an exposed metal tip at one end. A length of coaxial cable links the head to a termination, which includes an output connector for attaching the probe to an oscilloscope or other test instrument. In use, the metal tip is pressed against a component lead or circuit test point to pick up the signal (if any) present at that point. Most modern probes have interchangeable tips in a variety of configurations, including retractable hook tips for convenient attachment to small wires and component leads.

To avoid significant circuit loading, the input impedance of a voltage probe should be at least two orders of magnitude greater than the circuit impedance. In a passive probe this is achieved by incorporating a high value series resistor in the probe head, preferably near the tip to minimize input capacitance. Thus, for example, a probe designed for an oscilloscope having a 1 megohm input resistance may have a 9 megohm series resistor in the head, providing a ten times increase in input resistance (and a 10:1 reduction in signal amplitude). Compensation for high frequency signals is achieved by shunting the resistor in the probe head with a capacitor of suitable value. A variable capacitor is used if space permits, allowing the probe to be adjusted for variations in instrument input capacitance. Miniature and slim body probes employ a fixed shunt capacitor in the head, and circuitry is provided in the termination to adjust for instrument capacitance variations.

The trend in modern probe designs is toward the use of smaller heads with very slim bodies for convenience in testing crowded, high density circuits. Much less room is available in such heads for mounting the series resistor and shunt capacitor, necessitating the use of miniature components and making assembly more difficult and time-consuming. The difficulty is particularly acute in the case of high frequency probes, where the resistor and capacitor must be mounted as close to the tip as possible for minimum input inductance and capacitance. In prior art designs, the electrical components are soldered, welded or crimped directly to the inner end of the probe tip, producing a substantially rigid connection. This permits mechanical forces to be transmitted directly from the probe tip to the resistor and capacitor when the tip is physically stressed, as when it is pressed against a circuit test point during normal use of the probe. Even at values far below those sufficient to produce permanent damage, the transmitted forces can cause a temporary or permanent shift in the components' electrical characteristics. The resistor in the head of a miniature passive probe is particularly susceptible to transmitted shear forces because of its small size. Resistance variations of several percent have been observed to result from the strain gauge effect produced by such forces during normal probe use.

One way to reduce the coupling of mechanical forces into the probe head's internal electrical components is to connect them to the tip using a thin, flexible wire or conductive strip. Soldered gold foil connections have been used in some commercially-available probes, for example. However, this causes a significant increase in assembly time because the small size and close spacing of the various parts makes it difficult to solder or otherwise attach flexible conductors to them. In addition, electrical performance at high frequences may be adversely affected by increases in input capacitance and inductance resulting from the use of such connections.

SUMMARY OF THE INVENTION

The present invention is broadly directed to an improved electrical component assembly method and structure that has particular, though not exclusive, utility in the fabrication of electrical instrument probes. Such an assembly suitably may include a support structure, a spaced-apart pair of conductors dielectrically-supported by the structure, an electrical component disposed intermediate the conductors, and a pair of resiliently-deformable conductive bodies, each one compressively captured between the component and a different one of the conductors.

The invention is illustrated herein by its application to an attenuator probe head assembly in which the input resistor is effectively isolated from shear stress. As described below in greater detail, the resistor, in the form of a thick film deposit on an elongate ceramic substrate, is held in compression between a pair of resilient conductive pads disposed within a tubular housing. The pads are captured in a partially compressed state between the ends of the substrate and the adjacent inner end walls of spaced insulating members supporting signal input (tip) and output (tail) leads for the head. The leads extend through the insulating members and into contact with the resilient pads, which serve both to interconnect the ends of the resistor to the adjacent leads and to minimize or prevent the